CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-45

October 17, 1977

1. Name of fault: Northeast-trending faults in the Redlands-Yucaipa area, including such named faults as the Redlands fault, the Crafton fault, the Chicken Hill fault, and the Western Heights fault.

2. Location of faults: Yucaipa and Redlands quadrangles, San Bernardino County (figure 1).

3. Reason for evaluation: These faults are located within the 1977 study area of the 10-year program for fault evaluation.

4. List of references:

Allen, J.T., Jr., 1977, The geology of the Crafton Hills and lower Mill Creek Canyon: National Association of Geology Teachers, Far Western Section Annual Spring Meeting Field Trip Guidebook, pages 1-8.

(Contains a brief discussion of the Crafton fault.)

Burnham, W.L., 1960, Geology and ground-water hydrology of the Redlands-Beaumont area, California, with special reference to ground-water outflow: U.S. Geological Survey Open File Report. Map scales 1:40,000 and 1:48,000.

(This report provides the overall best descriptive coverage of the faults.)

California Division of Mines and Geology, 1974, Special Studies Zones Official Map, Yucaipa Quadrangle. Scale 1:24,000.

(The northeasternmost 3 km of the Chicken Hill fault has been zoned under the "Quaternary displacement" criterion.)

Dibblee, T.W., Jr., 1968, Geologic map of the Yucaipa quadrangle, San Bernardino County, California: U.S. Geological Survey Open File Report. Map scale 1:62,500.

(He shows only the Redlands and Crafton faults, and these he shows entirely dotted.)

Dutcher, L.C., and Burnham, W.L., 1959, Geology and ground-water hydrology of the Mill Creek area, San Bernardino County, California: U.S. Geological Survey Open File Report. Map scale 1:24,000.

(This report is not particularly useful for A-P purposes.)

Dutcher, L.C., and Burnham, W.L., 1960, Geology and ground-water hydrology of the Redlands-Beaumont area, California, with special reference to ground-water outflow: U.S. Geological Survey Open File Report. Map scale 1:24,000.

(Their map (their figure 3, scale 1:24,000) is probably the best and most useful for the purposes of this study.)

Dutcher, L.C., and Fenzel, F.L., 1972, Ground-water outflow of the San Timoteo-Smiley Heights area, upper Santa Anna Valley, southern California: U.S. Geological Survey, Water Resources Division, Open File Report. Map scale 1:24,000.

(This report adds no useful information beyond what has been provided in earlier reports.)

Eckis, Rollin, 1934, South coastal basin investigation, geology and ground water storage capacity of valley fill: California Division of Water Resources Bulletin 45, 279 p. Map scale 1:150,000.

(His map is the first to show faults in the area. He shows faults that appear to correspond to parts of the Chicken Hill and Western Heights faults. He says nothing about these faults in his text.)

Fife, D.L., D.A. Rodgers, G.W. Chase, R.H. Chapman, and E.C. Sprotte, 1976, Geologic hazards in southwestern San Bernardino County, California: California Division of Mines and Geology Special Report 113, 40 pages. Map scale 1:48,000.

(The map (plate 1B, scale 1:48,000) shows all of the faults, but it is all compiled from the maps of previous workers. Nothing is said about these faults in the text other than mentioning their existence.)

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology Data Map Series, Map no. 1. Scale 1:750,000.

Moreland, J.A., 1970, Artificial recharge, Yucaipa, California: U.S. Geological Survey, Water Resources Division, Open File Report. Map scale 1:62,500.

(His fault mapping is the same as that of Dutcher and Burnham (1960). He briefly discusses the Chicken Hill fault.)

Rasmussen, G.S., 1977a, Engineering geology investigation, Yucaipa towncenter, phase III and IV: unpublished report prepared for WES Engineering, San Bernardino, California, 15 p. Map scale 1:24,000. C-260?

Rasmussen, G.S., 1977b, Engineering geology investigation, 45 acre parcel, SW corner of Tenth and "D" Streets, Yucaipa, California: unpublished report prepared for C-Y Development, Redlands, California, 18 p. Map scale 1:24,000. C-259

Real, C.R., Parke, D.L., and Toppozada, T.R., 1977, Magnetic tape catalog of California earthquakes, 1900-1974: California Division of Mines and Geology.

Smith, R.E., 1959, Geology of the Mill Creek area, San Bernardino County, California: unpublished masters thesis, University of California, Los Angeles, 61 pages. Map scale 1:12,000.

5. Summary of available data:

The map of Dutcher and Burnham (1960) is by far the best reference for the location of the faults. They located the faults on the basis of surface topography, actual exposure of the faults, and subsurface water barriers. The maps of most of the subsequent workers appear to be compiled from the above map. Douglas Morton (personal communication, 10-7-77) says he has completed primary mapping of the Yucaipa and Redlands quadrangles at a scale of 1:24,000, but these maps are not available to the writer at this time (they are now undergoing review for release as U.S. Geological Survey Open File Reports.)

Basically, there are four northeast-trending faults (figures 3A and 3B) in this area that are known on the basis of surface features: the Chicken Hill fault, the Western Heights fault, the Crafton fault, and the Redlands fault. There are several other faults that are known

only as subsurface water barriers. In the discussion that follows, the data on each fault is presented, one fault at a time. The Chicken Hill fault is discussed in two parts, that which is northeast of Oak Glen Creek, and that which is to the southwest. This is done because there is some question as to whether these segments are part of the same fault; the two segments exhibit opposite senses of displacement.

Chicken Hill fault, northeast of Oak Glen Creek

Burnham (1960, p. 117) says, "The Chicken Hill fault is exposed nearly continuously along the southeast side of the Crafton Hills, extends southwest across Oak Glen Creek, and is exposed locally along the west margin of the Yucaipa Plain." The fault along the west margin of the Yucaipa Plain apparently refers to the southwestern segment of the Chicken Hill fault as defined above. He also says (p. 117), "Small scarps marking the fault line cut the alluvial benches north of Oak Glen Creek."

Regarding the fault-generated surface features, Burnham (1960, p. 117) says, "The trace of the fault is marked by a broad zone of intense shearing along truncated ridge spurs and by a lush phreatophyte growth in the canyons." Moreland (1970, p. 11) says, "Truncated ridges, shear zones, and vegetation in canyons mark the trace of the fault." He also mentions small scarps in older alluvium near the northeastern end of the fault. Smith (1959, p. 51) describes the fault as follows:

> On the southeastern side of Crafton Hills, a set of parallel faults form a fault zone. The actual width of the zone is uncertain because the eastern slivers are buried under the Yucaipa floodplain, but the exposed width is about 2,500 feet. Most of the faults are fairly small but at the base of the hills there is a blue gouge zone about five feet wide. About 300 feet east of the base of the

hills, blue gouge was penetrated in a well at 300 feet depth; this gouge may be either part of the five-foot wide gouge zone at the base of the hills, or it may be a separate fault.

None of the references say anything about the attitude of the fault except Smith (1959, p. 52). He states, "... the dip of this fault would be slightly east, but the general dip appears near vertical with preference given to southeasterly over southwesterly dips." Later, on the same page, he states that if the fault is not a left lateral strike-slip fault, then, "... the fault may be a reverse fault as the eastern block is downthrown." This implies a northwesterly dip, a contradiction to what he said earlier.

Regarding the sense and magnitude of movement, Burnham (1960, p. 117) says, "The fault has uplifted the crystalline rocks of the Crafton Hills against the older alluvium along a remarkably straight line." "A minimum displacement along the fault of at least 900 feet, down on the east, is indicated opposite well 1s/2-25M2 which bottomed at an altitude of 1,830 feet above sea level and did not encounter the basement complex which crops out only 1,300 feet away, west of the fault, at an altitude of 2,700 feet above sea level."

Regarding the recency of movement along this fault, Smith (1959) does not state what units are, or are not, cut by the fault. He seems to imply that most or all of the faulting occurs in basement rock, and that the south eastern side of the fault zone is buried beneath the alluvium. His map shows 90 percent of the fault as "concealed". Where he indicates a surface fault trace, it cuts Pleistocene "terrace" deposits or forms the contact between the terrace unit and crystalline basement rock.

Both Burnham (1960, p. 117) and Moreland (1970, p. 11) state that the fault offsets "older alluvium" in various places, but neither of them says anything about the age of the older alluvium. The legend of the map of Dutcher and Burnham (1960) shows older alluvium (Qoa) as Pleistocene age. That map shows "older" alluvium as the youngest unit cut by the fault, and "younger" alluvium as the oldest unit not cut by the Chicken Hill fault. Unnamed ground water barrier faults just east of the Chicken Hill fault are shown not to cut both younger and older alluivum.

The part of the fault that was mapped by Smith (1959), was included as a special studies zone (California Division of Mines and Geology, 1974, Yucaipa quadrangle). Although Holocene activity along this fault segment is questionable, it is very probable that there has been Quaternary activity. In 1974, the criterion for calling a fault potentially "active" was Quaternary movement; on that basis the fault was zoned.

Chicken Hill fault, southwest of Oak Glen Creek

This fault segment lies mainly to the south of Yucaipa Blvd., and appears to be associated with an erosional scarp along the southwestern margin of the Oak Glen Creek flood plain. The references give little information about the surface character of the fault, and do not indicate on what basis a surface trace was mapped. Moreland (1970, p. 11) states, "The effect of this fault as a barrier to ground-water flow is well established south of Yucaipa Boulevard. Prior to the pumping of ground water from the basin, springs and peat bogs occurred along the fault where rising ground water flowed across the barrier. Water-level declines caused by pumping have created water-level differences of 100 to 200 feet across the fault."

He is not clear as to the location of these features. Rasmussen (1977b) exposed the fault, or a branch of the fault, in trenches along the southeast side of Oak Glen Creek.

None of the workers say anything about the attitude of the fault except Rasmussen (1977b). His trench logs show the fault dipping to the northwest at angles ranging from 50° to 58°. He also says that the major movement along this part of the fault appears to have been down on the northwest, making it a normal fault. His trench logs suggest that, locally, the land surface and the upper 3 m of alluvial strata has been offset vertically by at least 3 m. Moreland (1970, p. 11) says that, on the basis of geophysical data, the west side of the fault is downdropped.

Rasmussen (1977b, p. 9) observed the fault to cut alluvial sediments within three feet of the ground surface. He believes that the alluvial material, to a depth of at least 11 feet, is of Holocene age. He states (p. 9), "Therefore, the Chicken Hill fault is considered to be an active fault ...". He also defines (p. 10) his use of the term "active" as meaning that displacement has occurred during Holocene time (past 11,000 years).

Western Heights fault

Rasmussen (1977a) named this fault. He observed a southeast-facing modified scarp near the point of intersection of the fault with West Yucaipa Boulevard. He observed the fault disrupting alluvium within three feet of the surface in a trench in the same area. Burnham (1960, p. 121) says of this fault, "Several small scarps and a closed depression, or sag, mark the trace of a northeast-trending fault zone along the northwest edge of the Yucaipa Valley." Douglas Morton (personal communication, 10-7-77) said that a series of scarps associated with this fault zone was probably the youngest of the northeast-trending fault features in the Yucaipa-Redlands area. The trench log of Rasmussen (1977a) shows a fault trending N 67° E and dipping 58° southeast. He shows the southeastern side downthrown with an apparent vertical offset of at least 3 m. The attitude and sense of offset is the same along this fault as that ascribed to the northeastern segment of the Chicken Hill fault; these two segments may be structurally continuous with one another.

Rasmussen (1977a) p. 10) states that he considers this fault to be active. He defines his use of the term "active" (p. 9) as meaning that displacement has occurred during Holocene time (past 11,000 years). The map of Dutcher and Burnham (1960) shows this fault cutting older alluvium and locally forming the contact between older alluvium and very old alluvium. That map also shows a sub-parallel fault that lies 300 to 400 m southeast of the Western Heights fault. That fault is shown cutting older alluvium, and locally forming the contact between older alluvium and younger alluvium. They also show another sub-parallel fault lying another kilometer farther south. That fault is shown to cut

older alluvium and very old alluvium, except the easternmost 300 m of the fault which is shown cutting younger alluvium. No mention of that is made by Dutcher and Burnham (1960) in their text, nor by any of the other references used in this report.

Crafton fault

Burnham (1960, p. 131) says, "It forms the western front of the Crafton Hills and Brown Butte, and is marked by a sharp escarpment ..." Allen (1977, p. 3) says, "The surface displacement across the escarpment is as much as 120 feet just northeast of Sand Canyon, but the logs of wells indicate that the displacement of the basement complex is much greater; about 400 feet at least." Nowhere do any of the references actually state that the fault cuts the surface or is anywhere exposed. However, all of the maps that show this fault, except that of Dibblee (1968), imply that the fault extends to the surface, because they use a solid or dashed line. The southeast side of the fault is apparently the upthrown side, but no information is given regarding the attitude of the fault.

Regarding recency of displacement, Dutcher and Burnham (1959, p. 103) say,"The fault displaces the older alluvium and the older plain and bench deposits, but it is believed not to displace the younger alluvium." That is the only statement in any of the references about the recency of movement along the fault. The map of Dutcher and Burnham (1960) shows the Crafton fault cutting units as young as older alluvium. Younger alluvium is the oldest unit not cut by the fault, except at the extreme northern end where they appear to show the fault not cutting older alluvium.

Redlands fault

Burnham (1960, p. 115-116) provides the only useful discussion of this fault:

> The Redlands fault can be traced as an exposed fault zone or as a fault-line scarp across the south edge of the City of Redlands from San Timoteo Canyon northeast to 1S/3-25N. Two subsurface structural features, not exposed at the land surface, extend north-northeast and northeast from this point. One is aligned with the Redlands fault and extends northeast to the Crafton fault; the other has been named the Mentone fault (figure 3). Both have been defined only from well logs and from their effect on ground-water movement. The Redlands fault extends about N. 75° E. from 1S/3-25N to the Crafton fault at the north edge of 1S/2-29, passing between wells 1S/2-30G1 and 1S/2-30G1 and 1S/2-30H1 and south of 1S/2/29C1. As shown by the bedrock contours (figure 10) and the cross section D-D' (figure 4), the basement rocks which are shallow beneath the Mentone subbasin appear to be faulted down on the south along the Redlands fault. The fault coincides also with a break in the water-level slope in the same area (figure 9).
>
> South of Smiley Heights the Redlands fault is well-exposed in a cliff 200 feet high which forms the north bank of San Timoteo Canyon. Several parallel lines of cemented fracture zones strike N. 60° E. and dip 65° N. The shear planes are well cemented with lime(calcium carbonate), and on the southeast side of the fault the cementation extends along gravel stringers to form conglomerate beds which pinch out a short distance from the fault. No reliable marker beds are present in the massive San Timoteo beds of Frick (1921) on either side of the fault, but the contact between the San Timoteo beds and the overlying old red gravel appears to be displaced at least 40 feet and possibly as much as 100 feet downward on the north, opposite the displacement near the Crafton fault. The fault zone is concealed by the younger alluvium southwest of these exposures, but based on the water-level measurements, the water-level profile H-H' (figure 7) it is probable that a barrier action exists along its trace at least as far as the Banning fault.
>
> The eroded scarp of the Redlands fault is most pronounced at the southwest side of Reservoir Canyon where it forms a bluff 60 to 80 feet high (figure 5). Small fractures associated with the fault are exposed in the highway cut at the canyon mouth, and the position of the fault plane can be closely defined from water-level data.

He mentions no evidence indicative of Holocene displacement along this fault. The map of Dutcher and Burnham (1960) shows the surface trace cutting units as young as older alluvium. Along the two subsurface

water barriers to the northeast, units as old as older alluvium are not cut by the faults at the surface.

Seismicity

The 1900 to 1975 distribution of epicenters (figure 2) shows no particular relationship to the faults considered in this FER. Only the Casa Blanca subsurface water barrier appears to be associated with a cluster of epicenters. These epicenter locations, however, are of combined A and B quality, meaning that an accuracy of plus or minus 5 km must be assumed for their plotted positions.

6. Interpretation of aerial photography: None.

7. Field observations: None.

8. Conclusions:

Based on the literature, at least part of each of the five faults discussed is sufficiently well-defined for our purposes. However, the question of recency is largely unanswered. Only the Western Heights fault and the southwestern part of the Chicken Hill fault are strong candidates for classification as Holocene faults.

It would be unsafe, however, to make the assumption, based on the literature, that the Redlands and Crafton faults have not had Holocene activity. The general character of what the writers had to say about those faults suggests to me that they had little predilection for evaluating the recency of faulting using the criteria that we require.

9. Recommendations:

On the basis of the literature reviewed, I would recommend that only the Western Heights fault and the southwestern segment of the Chicken Hill fault be zoned. For the Western Heights fault, I would limit the zoning to the more northwesterly of the two traces shown on figure 3a. That is the trace that Rasmussen (1977b) trenched. I recommend a high priority for aerial photo and ground examination of all of the Chicken Hill fault (with consideration for rezoning the northeastern segment) and the Western Heights fault. I recommend that the remaining faults be examined on aerial photography and, where warranted, on the ground before any decision is made about zoning.

10. Investigating geologist's name and date:

Drew P. Smith

DREW P. SMITH
Geologist
October 17, 1977

I concur with the recommendations that parts of the Chicken Hill and Western Heights faults warrant consideration for zoning and the zoned northeast segment of the CH fault be re-evaluated. Please give this a high priority. A low to moderate priority is given for the other faults, which do not appear to warrant zoning under existing criteria.

GHC
11/23/77

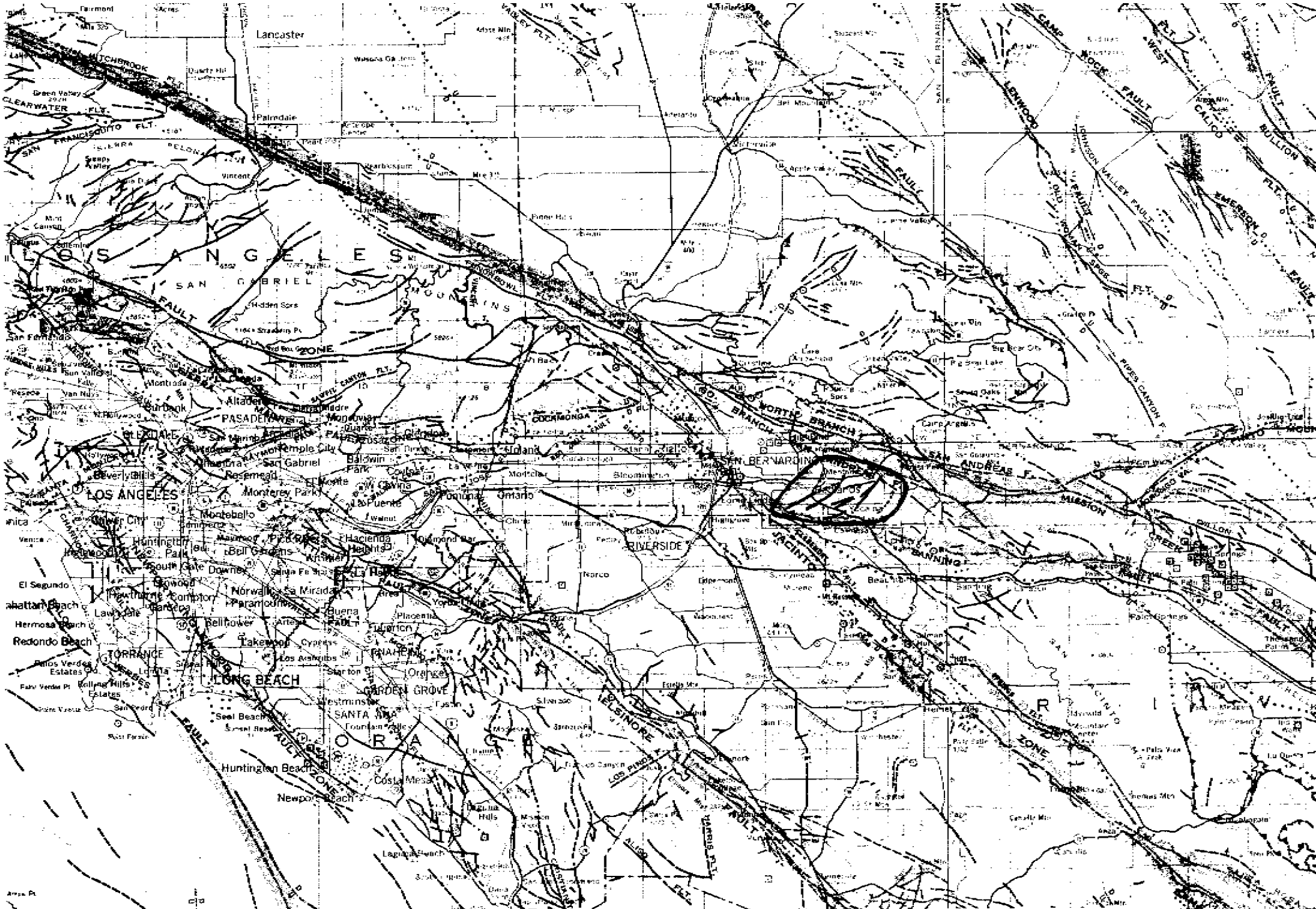

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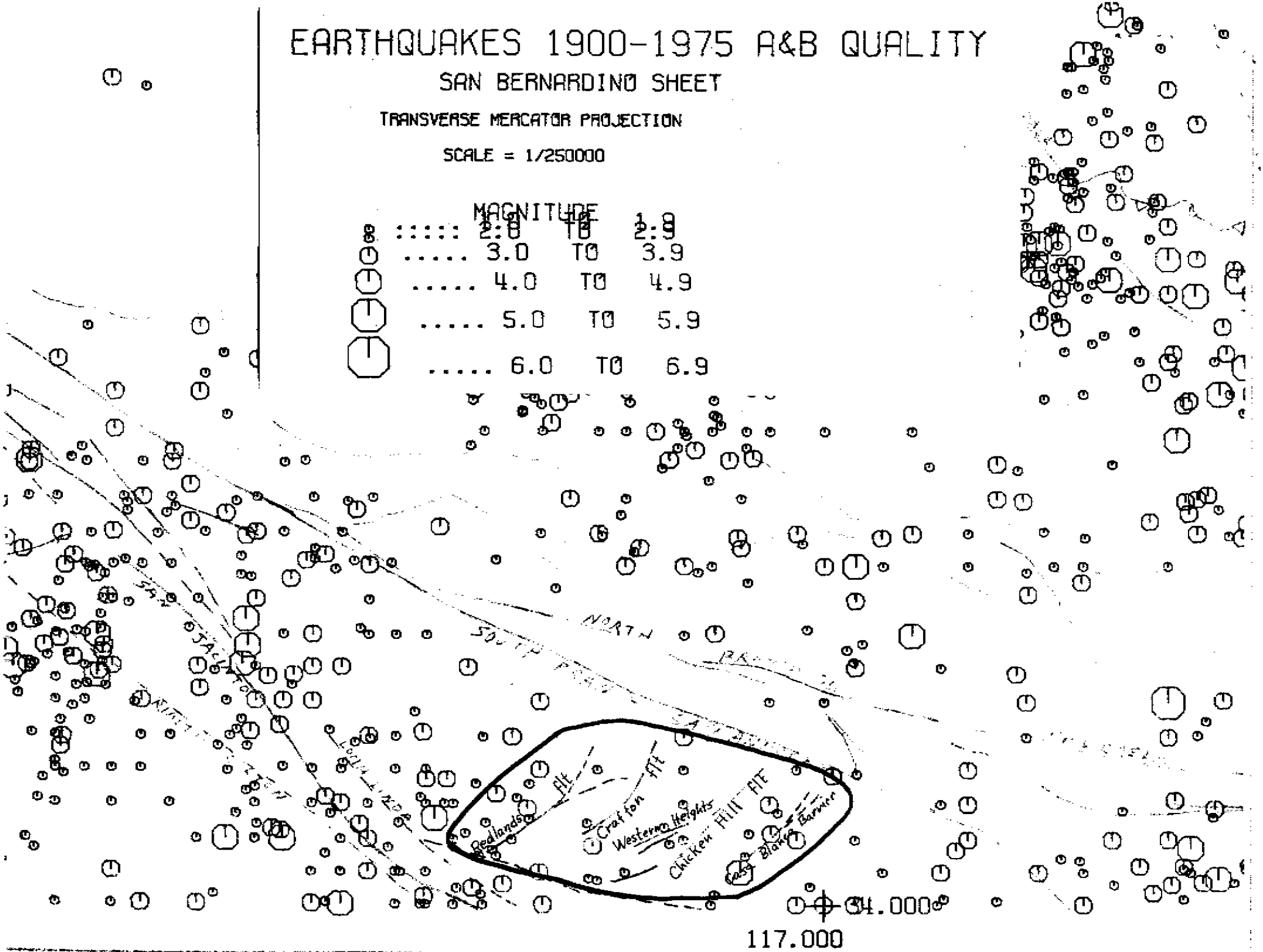
Figure 1. Index map showing locations of the northeast-trending faults in the Relands-Yucaipa area. Map is modified from Jennings (1975).



FER 45 Figure 2. Seismicity in the Yucaipa-Redlands area. From Real, et al (1977).

FERL 45

State of California

The Resources Agency

Memorandum

To : Earl W. Hart

Date: July 6, 1978

Telephone: ATSS (597) 3194
(557) 3194

From : **Department of Conservation**
Division of Mines and Geology—San Francisco 94111

Subject: A site investigation report by Pioneer Consultants, dated June 7, 1978, for a property at Juniper Avenue and Bryant Street, Yucaipa area, San Bernardino County, California.

I examined the site on 1952 stereo photography (GSVR, frames 7-51 and 7-52, flown on 7/13/52) and see no topographic indication of the east-west-trending fault trace that these consultants have located. Their large-scale topographic base map (their "Plan Sheet") also shows no topographic features associated with their fault. The land surface in this area is an abandoned alluvial fan that is now well entrenched. The specific part of that surface, beneath which their fault passes, has probably not seen significant deposition or erosion since early Holocene time, or even earlier. Therefore, any faulting that has occurred there is almost certainly pre-Holocene.

I examined their trench logs, but the logs belie their interpretations. What they refer to as a "rupture zone" appears to be a filled erosional channel. Deep channels such as these, with near-vertical walls, can form in this type of alluvial material during certain types of winter storms. I personally observed this type of erosion in the Yucaipa area after the storms of January and February, 1978. These channels usually fill up again with locally-derived alluvium in subsequent winters. On the basis of their trench logs, I believe their interpretation that a fault exists here is incorrect. If this is a fault zone, it should project eastward to the roadcut on the eastern side of Bryant Street. They make no mention of this.

Drew P. Smith

DREW P. SMITH
Geologist
San Francisco District Office

DPS/mkr